Salt Fork Stream Restoration Investigation

CEE 498 FM

Photo Courtesy of Bob Holmes

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Background

The Salt Fork watershed is located in Champaign and Vermillion Counties and is shown in Figure 1. The Salt Fork has its headwaters north of Rantoul and flows south toward Sidney where it flows to the east and eventually joins the North Fork of the Vermillion River to form the Vermillion River at Danville. Just upstream of St. Joseph the Saline Branch flows into the Salt Fork. The waters of the Saline Branch flow from urbanized Champaign-Urbana.

Intensive row-crop agriculture dominates the Salt Fork watershed. Before settlement here, this area was poorly drained. Upon the advent of channelization and agricultural drain tiles, intense cultivation of the land was able to take hold. The Saline Branch watershed has a large portion of agricultural land but also drains a portion of urban Champaign-Urbana.

The effects of rapid urbanization not only in Champaign-Urbana but also in the surrounding communities are felt in the Salt Fork. There are three wastewater treatment plants (WWTPs) in the Salt Fork watershed that discharge wastewater effluent into its waters, Rantoul, Urbana, and St. Joseph. Wastewater effluent not only enters the Salt Fork from these WWTPs, but also from individual septic tank systems. With urbanization, the Salt Fork can become impaired due to an increased volume of runoff from impervious areas and from chemicals and heavy metals carried by that runoff.

Agriculture can also impair waters within the watershed. The types of agriculture and practices used have different affects on water quality. Livestock operations may increase the bacteria levels within a reach. Fertilizing fields with manure may have the same effect. Applying excess fertilizer can increase the nutrient levels in the stream. When crops are down, more sediment is likely to be carried into the waters, unless sufficient crop residue is left on the fields.

Periodic maintenance dredging occurs today in the Salt Fork. When enough sediment is deposited in the Salt Fork to decrease the efficiency of agricultural field drainage, the Salt Fork is dredged. Phase one of dredging has already been completed as of 2005, upstream of the St. Joseph gage (03336900) (Figure 2). This dredging involved the removal of riparian trees. Phase two of the dredging is scheduled for the 2007-2008 time frame. If this dredging is allowed to occur it will destroy riparian habitat similar to what exists at the Sidney gage (03337848) (Figure 3). The extent of the phase two dredging will extend from the St. Joseph gage to a point not far upstream of the Sidney gage.

A Total Maximum Daily Load (TMDL) study has been ongoing in the Salt Fork Vermillion River Watershed as certain reaches have failed to meet their designated uses due to water quality impairment. In a July 2007 Draft TMDL for the Salt Fork Vermillion River Watershed prepared for the Illinois Environmental Protection Agency by LimnoTech, found that the water quality impairments for various reaches included dissolved oxygen, nitrate, pH, and bacteria (LimnoTech 2007).

The purpose of this study is to investigate streamflow and water quality conditions in the Salt Fork as part of a stream restoration investigation. Designated uses for reaches in the Salt Fork for the purpose of establishing water quality standards were found in the LimnoTech 2007 report. The site conditions in the floodplain at the Sidney gage were evaluated to determine the feasibility of implementing a stream restoration project in this area.

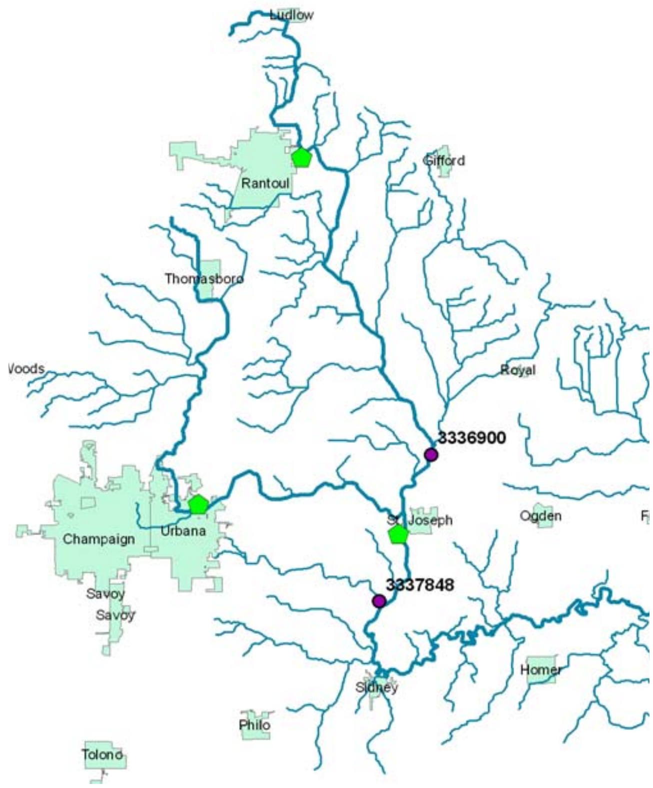

Figure 1: The Salt Fork and its Tributaries

Figure 2: Salt Fork at the St. Joseph Gage Looking Upstream (Photo Courtesy of Davide Motta)

Figure 3: Salt Fork at the Sidney Gage (Photo Courtesy of Davide Motta)

Streamflow

Streamflow conditions in the Salt Fork were investigated as part of the stream restoration investigation. These included generating a rating curve at the Sidney gage to determine the discharge for any stage and developing a flow duration curve for the Sidney gage to determine the exceedence probability for any discharge. These tools allow anyone to determine the probability a certain discharge will be exceeded at the Sidney gage and similarly the stage. The bank-full streamflow discharge is when the channel begins to overflow onto its floodplain. The low-flow hydrology shows the impact the WWTPs have on the 7-day-low-flow. This shows what percentage of streamflow during a low-flow event is effluent from the WWTPs. The bed and bank stability qualifies and attempts to quantify the variability of near-bed shear stresses within a cross-section of the Salt Fork near the Sidney gage. The shear stress is an indicator of where erosion and deposition are occurring in the channel. Lastly, seepage determines the affects of groundwater/surface water interactions on the flow in the Salt Fork.

Sidney Rating Curve

A rating table and curve for the Sidney gage was generated using simultaneous discharge and gage height data collected by Bob Holmes over the past few years (Table 2 in the Appendix and Figure 4). The discharge measurement and gage height record was plotted on a log-log scale. Values that appeared to fit a smooth curve were used by the interpolate function, within the XLXtrFun function package for Microsoft Excel, to generate a rating table and curve. This was generated using a smooth double parabolic curve that used adjacent points to aid in curve fitting. The interpolation generated discharge values for stage between 0.88 and 11.08 feet with 0.01 foot increments.

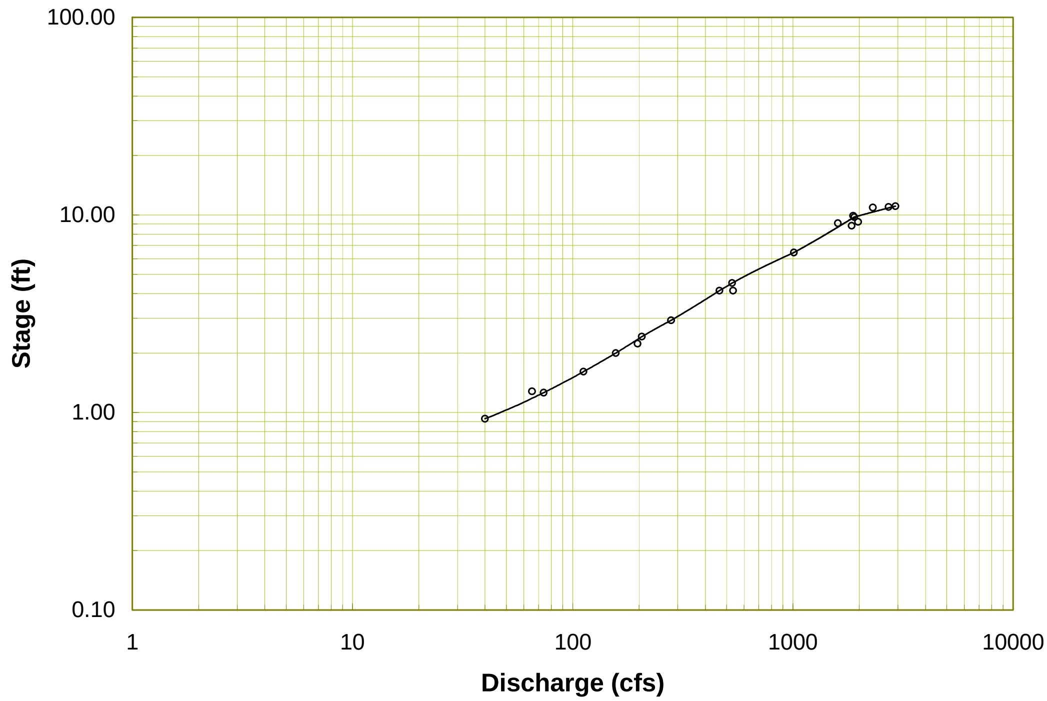

Figure 4: Salt Fork at Sidney Rating Curve

Flow Duration Curves

Using the generated rating table for Sidney and the 15 minute stage data provided by the USGS, 15 minute discharge values were generated for June 1st through the 22nd of 2007. This discharge data was appended to the Sidney discharge data obtained from the USGS for Sidney's period of record through May 2007. This 15 minute data was then averaged into daily values for Sidney's period of record through June 22nd of 2007. Daily values for the long-term gaging station at St. Joseph were obtained from the USGS historical flow record. Concurrent daily discharge values at each site were used to determine their relative flow duration curves (Figure 5).

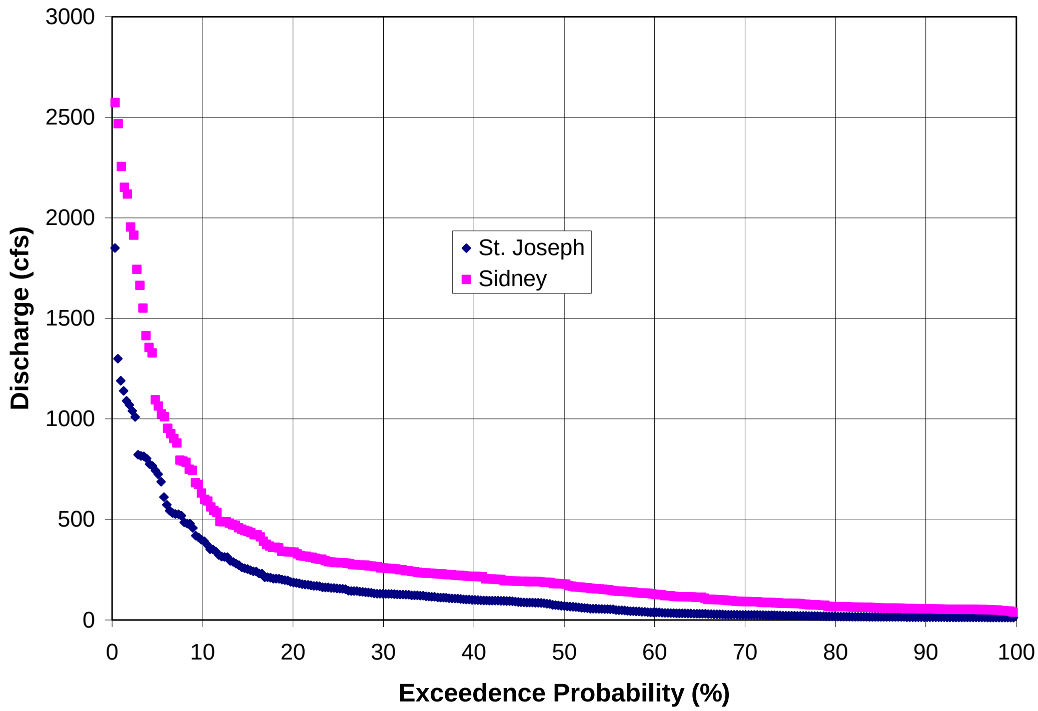

Figure 5: Relative Flow Duration Curves

The long-term flow duration curve for the gaging station at St. Joseph was used to synthetically extend the flow record at Sidney. For the period of record when both gages operated simultaneously, missing data was filtered out to determine the exceedence probability for a given flow. Whole number exceedence probabilities were then interpolated from 0 to 100 for each gaging station for a direct comparison. The ratio of flow between Sidney and St. Joseph was computed for each probability to obtain a shift factor. Using the entire period of record for the long-term gaging station at St. Joseph, the exceedence probability was determined for the flow. Whole number exceedence probabilities were then interpolated from 0 to 100. The flow for each exceedence probability at St. Joseph was multiplied by the shift factor to obtain the extended flow duration curve at Sidney (Figure 6).

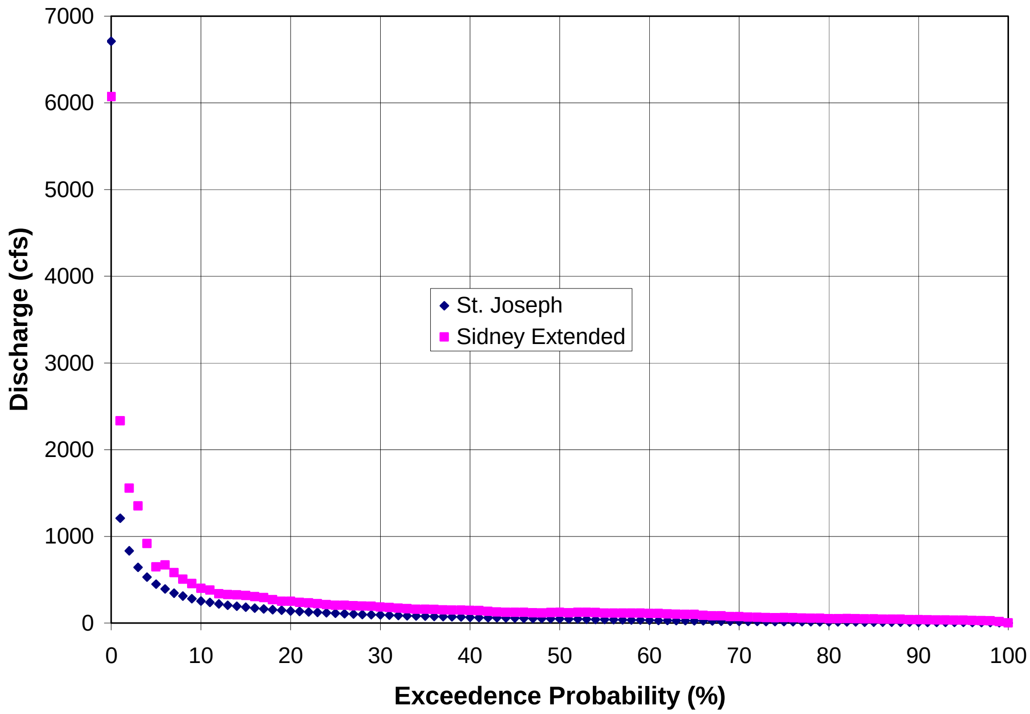

Figure 6: Extended Flow Duration Curves

Bank-Full Streamflow Discharge

An estimation of the bank-full streamflow discharge within the Salt Fork can be made from a rating curve. Stage increases linearly with discharge in the channel. As the discharge increases, eventually the slope of the linear relationship reaches a breaking point. After this point the linear relationship follows a diminished slope which represents over-bank flow. At the breaking point the relationship between stage and discharge changes, which represents the bank-full streamflow discharge. From the generated Sidney rating curve, Figure 4, and the St. Joseph rating curve provided by the USGS, Figure 7, the bank-full streamflow discharge can be estimated at approximately 2000 cfs.

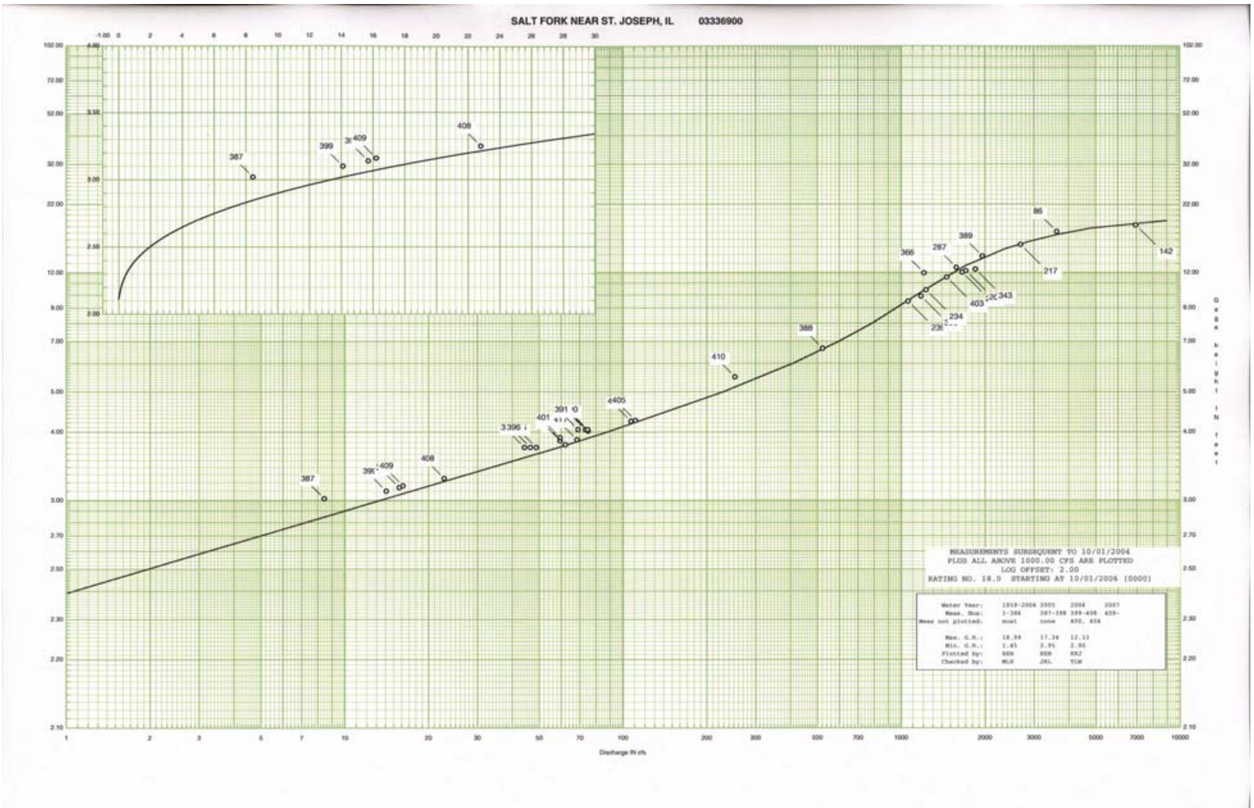

Figure 7: Salt Fork at St. Joseph Rating Curve

Low-Flow Hydrology

The 7-day-low-flow was determined for the period of record when the St. Joseph and the Sidney gage operated simultaneously. The 7-day-low-flow period was based on streamflow data from the St. Joseph gage. These low flows were compared to wastewater treatment plant (WWTP) effluent discharges for three WWTPs tributary to the gages. The WWTP effluent discharge data was provided courtesy of the respective WWTPs. The WWTP in Rantoul is the only WWTP tributary to the St. Joseph gage. The WWTP at Rantoul, Urbana, and St. Joseph are all tributary to the Sidney gage. The 7-day-low-flow at each gage was plotted with the tributary WWTP effluent discharge (Figure 8). The percentage shown is the WWTP effluent discharge tributary to the gage as a percentage of the measured discharge at the gage. During the 7-day-low-flow, WWTP effluent discharge was a significant percentage of total flow measured at each gage. For the gage at Sidney on October 2, 2006, WWTP effluent discharge was over half of the total discharge. The bulk of the WWTP effluent discharge was from the Urbana WWTP. This increase in WWTP effluent discharge as a percentage of measured discharge can be seen from the St. Joseph to the Sidney gage.

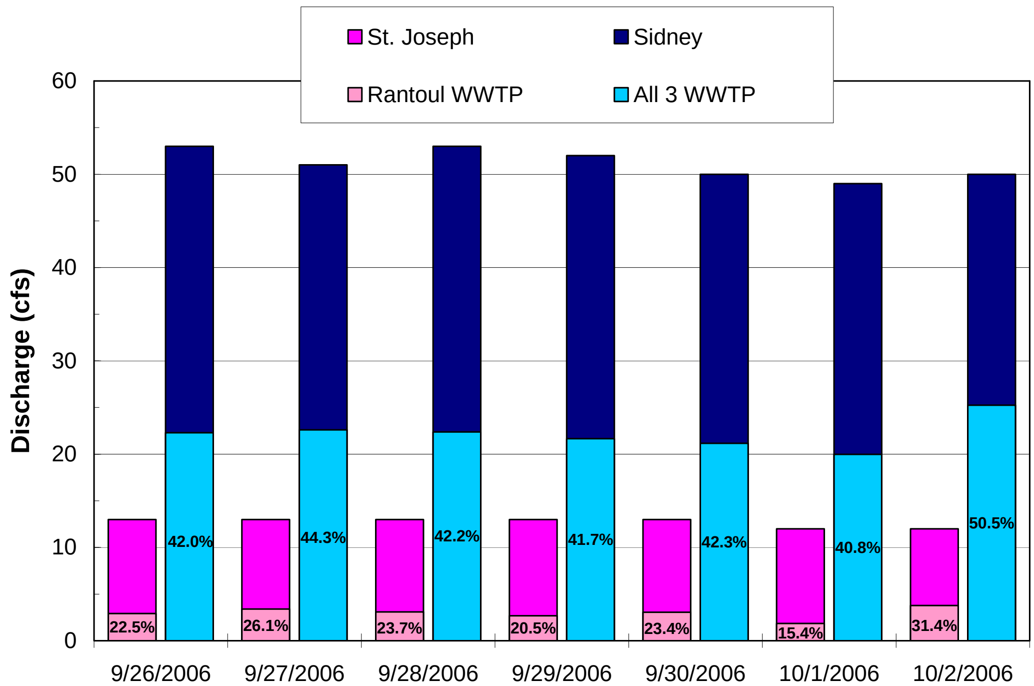

Figure 8: 7-Day-Low-Flow of WWTP Effluent as a Percentage of Measured Discharge

Bed and Bank Stability

Bed and bank stability is important in a stream restoration investigation. A cross section taken at the Sidney gage was used in determining the bed and bank stability of the Salt Fork. This cross section is deeper near the banks and shallower in the center of the channel (Figure 9). Two Nortek Acoustic Doppler Velocimeters (ADVs) were each mounted to a saw-horse for stability and placed in the river (Figure 10). One was placed in the middle of the channel and the other was placed near the right bank. The probe placed in the center of the channel was a 10 cm probe with serial number 349. The probe placed near the right bank of the channel was a 5 cm probe with serial number 388. Velocity data was collected using CollectV and during data collection unexpected spikes in the velocity data were encountered. The probes were positioned near the bed and velocity data was collected for over 30 minutes. The probes were then raised a few centimeters and more data was collected. This was done one more time resulting in three different points for each probe.

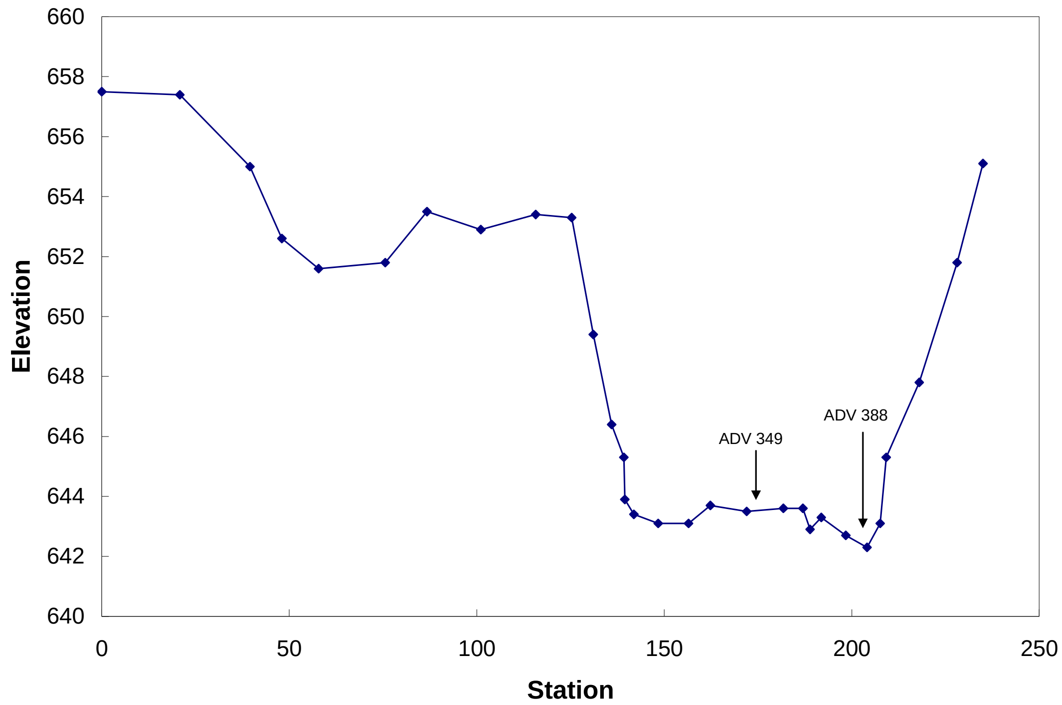

Figure 9: Channel Cross Section at the Sidney Gage with ADV Locations

Figure 10: ADV Locations at the Sidney Gage (Photo Courtesy of Bob Holmes)

Once the data was collected it was processed using WinADV. Upon reviewing the component velocities, it appeared that the probe beam arm alignment was altered upon changing the distance from the probe to the bed. The beam that computed the x-velocity component should have been positioned parallel to the flow and therefore should have shown the highest velocity. The raw data suggests otherwise. The data was reprocessed with a shifted xy-plane such that the x-velocity component was the highest.

Bed shear stress was used as an indicator for bed stability. The bed shear stress was calculated based on the velocity data. One method employed was the extrapolation of Reynolds stresses to the bed (Holmes 2007). Reynolds stresses were computed from the covariance between x and z velocity fluctuations, which WinADV produced in a statistical summary table, and the density of water computed at a temperature of 28ºC, which was recorded in the field notes. A value for bed shear stress was extrapolated from this data (Figure 11). For the probe near the right bank a bed shear stress of 3.2 dynes/cm^2 was calculated. For the probe in the middle of the channel, based on the data, a negative bed shear stress was calculated (Figure 12). This physically did not make sense. A further investigation into probe 349, which was in the middle of the channel, indicated that this method for computing Reynolds stress from the velocity fluctuations was inappropriate.

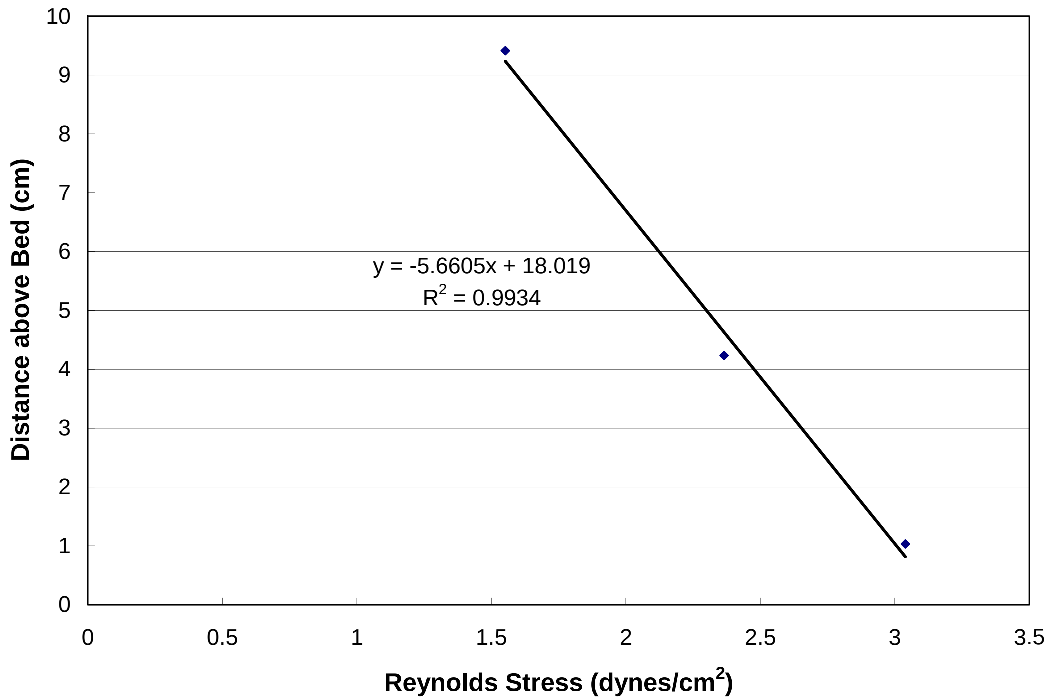

Figure 11: Extrapolation of Reynolds Stress to the Bed near the Right Bank

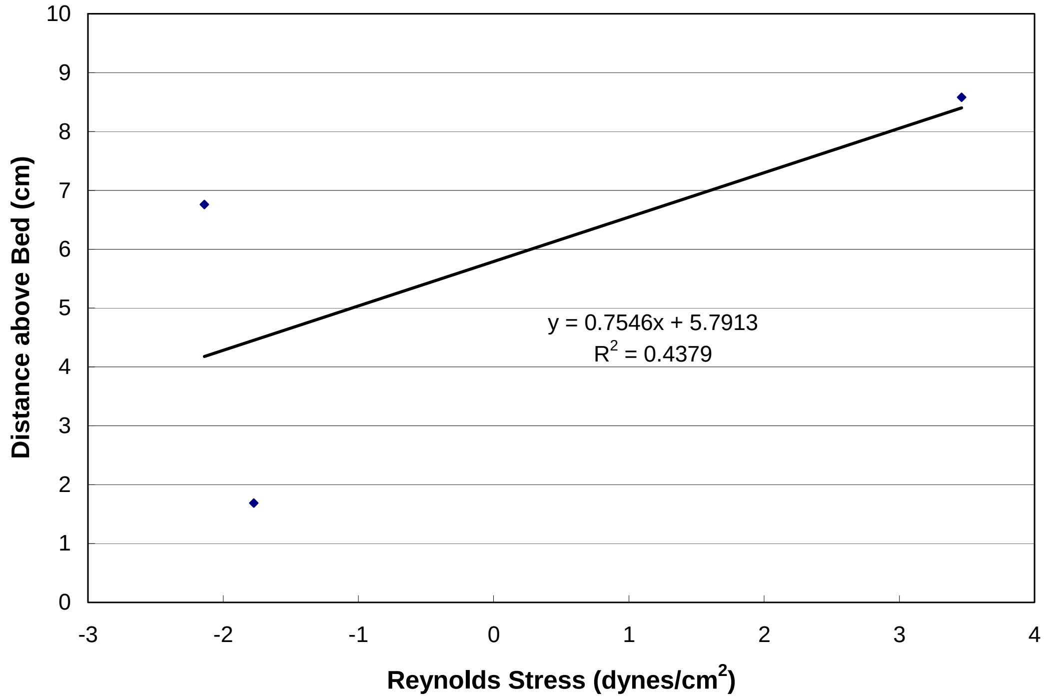

Figure 12: Extrapolation of Reynolds Stress to the Bed in the Middle of the Channel

A further investigation into Nortek ADVs, 349 and 388, was performed to determine if there were any problems with the beams. The probes were held in place by clamps and suspended in a 5-gallon bucket of water. Data was collected for two minutes using the Check probes diagnostic (NDVCHECK) in CollectV. These samples were averaged together to create Time/Distance vs. Signal Strength graphs. These plots show multiple peaks. The first peak is due to transmit noise. The second peak is due to the sampling volume. The third peak is due to the bottom echo. For diagnostic purposes, the second peak is the peak of interest. For the 10 cm probe (349) this peak is located at approximately 200 units and for the 5 cm probe (388) this peak is located at approximately 100 units. The Time/Distance vs. Signal Strength graphs for probes 349 and 388 are shown in Figure 13 and Figure 14 respectively. For probe 349 the sampling volume peak for beam 1 is offset (horizontally) approximately 10 units from the peaks of the other beams. According to Nortek, the receiver arm for beam 1 is bent. Therefore the velocity data obtained by probe 349 is noisy, more than what could be credited to turbulence alone, and can not be used to measure turbulence parameters. Probe 388 did not show any significant problems. Additional information on performing the test and interpreting the results can be found in the Nortek Manuals listed in the Reference section.

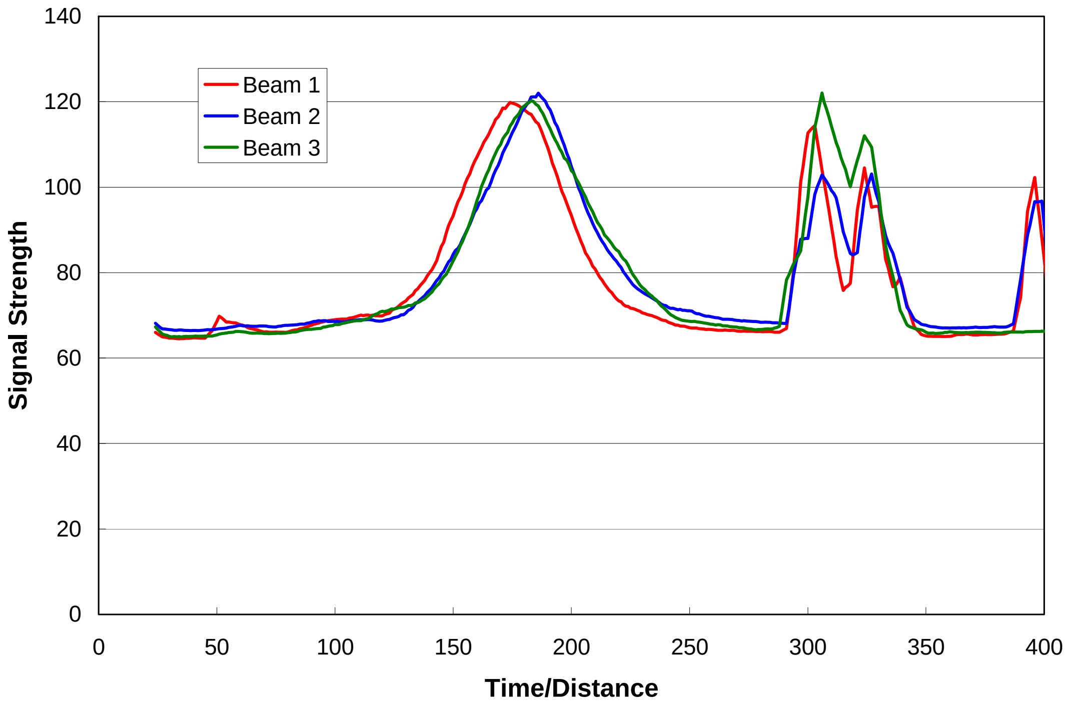

Figure 13: Probe Check for ADV 349

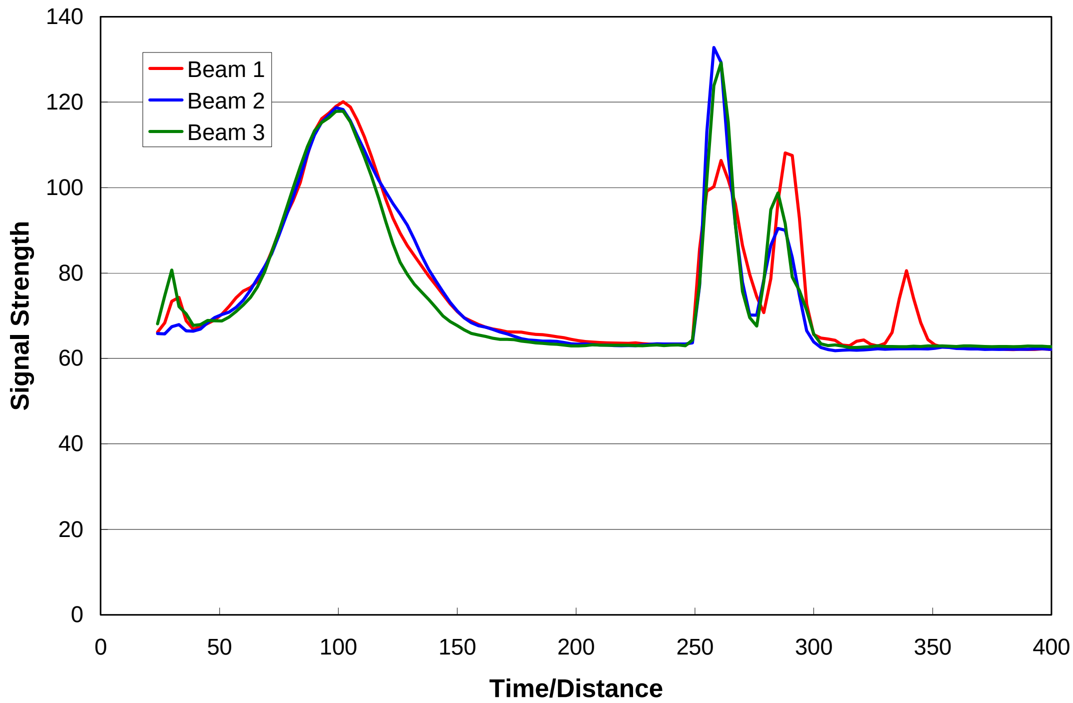

Figure 14: Probe Check for ADV 388

In order to compare the bed shear stress for the two locations spatially, another method was employed for calculating bed shear stress. The slope of best fit line through the velocity profile method was used to calculate a shear velocity (Holmes 2007). Processed average velocities in the x-direction downstream were used to compute shear velocity. For the calculation near the right bank all three data points were used and in good agreement (Figure 15). For the calculation in the middle of the channel only the two points nearest the bed were used because the third point did not fit the trend of the velocity profile coming off of the bed (Figure 16). The shear velocity was then squared and multiplied by the density of water at 28ºC to come up with a shear stress. For near the right bank a shear stress of 1.9 dynes/cm^2 was calculated and the middle of the channel a shear stress of 0.018 dynes/cm^2 was calculated.

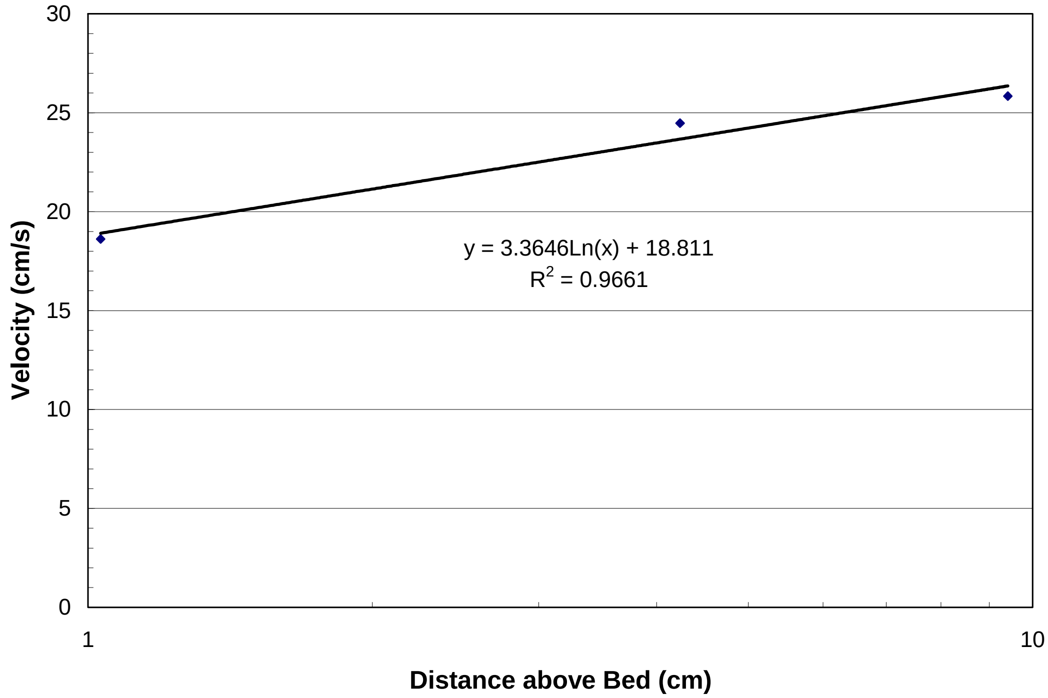

Figure 15: Slope of the Best Fit Line through the Velocity Profile near the Right Bank

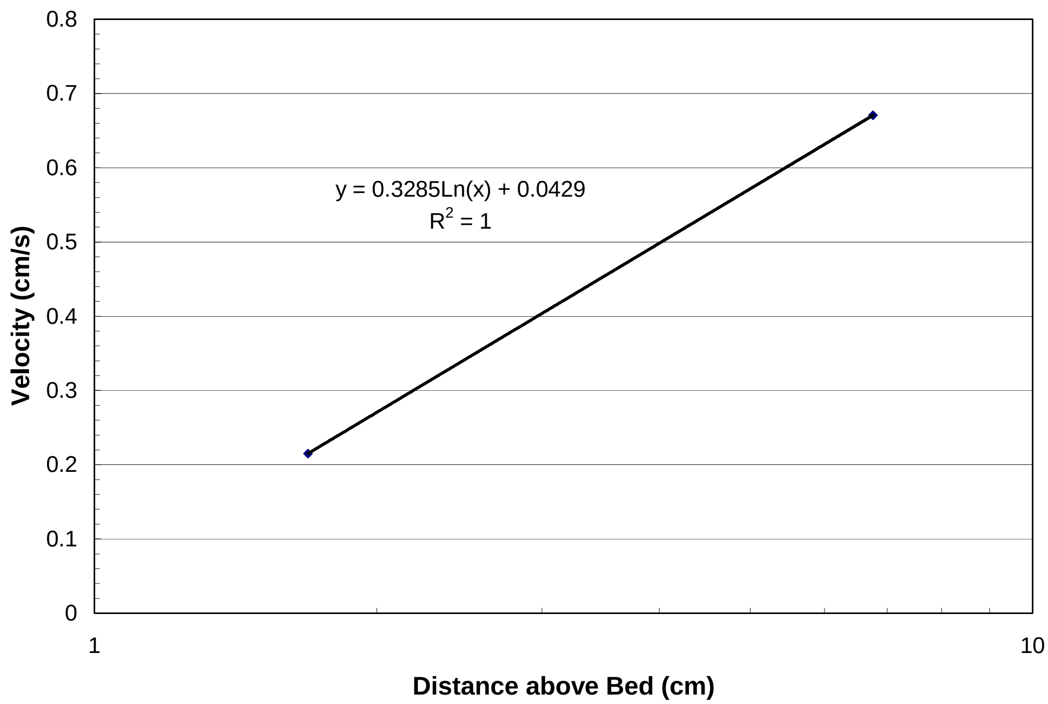

Figure 16: Slope of the Best Fit Line through the Velocity Profile in the Middle of the Channel

The calculated values for shear stress near the right bank differ quite a bit. The value obtained by the first method is probably more accurate because it is taken directly from the measured covariance of a good probe. Regardless of the numerical values, the important fact is that the shear stress near the right bank is higher than in the center of the channel. The relative shear stresses agree well with the physical characteristics of the channel. The measurement with the lower shear stress was taken on a bar while the measurement with the higher shear stress was taken in the thalweg.

Seepage

A seepage study was performed in an attempt to determine the significance of the groundwater/surface water interactions. Sites were selected within the study area (Figure 17). At each site a discharge measurement was made using a Flowtracker following standard USGS procedures (Figure 18). All of the measurements were made within a few hours of each other.

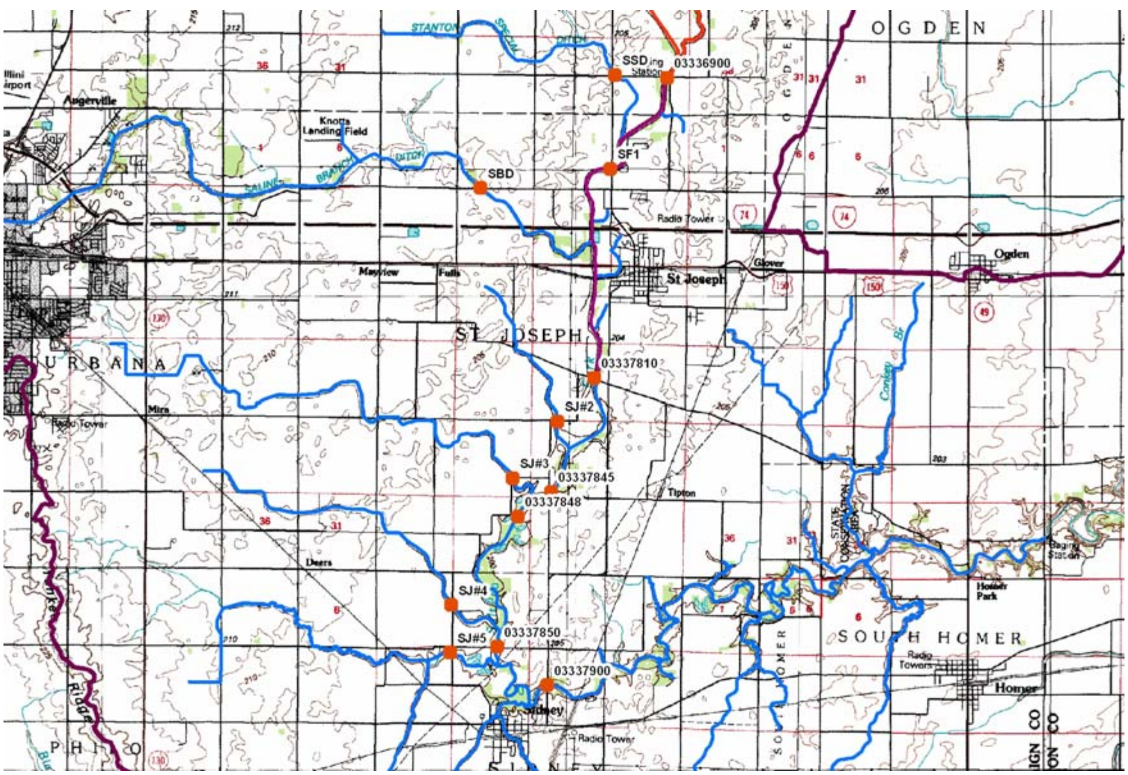

Figure 17: Seepage Study Sites

Figure 18: Art Schmidt Making a Flowtracker Measurement (Photo Courtesy of Art Schmidt)

Table 1 shows the measured discharge (Qm), the calculated discharge (Qc), and the discharge gained from groundwater (Qm-Qc). The Qc was calculated for sites along the main stem of the Salt Fork downstream of a measured tributary. The measured discharges of the upstream sites, the nearest upstream site along the main stem and the upstream tributary, were added together and compared to the measured discharge at the site (Qm-Qc). A positive value for Qm-Qc indicates the stream is gaining water from the ground and a negative value indicates the stream is losing water to the ground. These values were calculated for each major site along the main stem of the Salt Fork and then added together to determine a net result. Overall it appears that the Salt Fork loses very little water to the ground, but looking at each individual calculation, the Salt Fork gains water then loses then gains and then loses water again. It may be that some reaches gain water from the ground and some lose water to the ground. More likely, these results are just representative of the measurement noise. With such limited data it is difficult to say if the Salt Fork gains or loses water to the ground. But during the period of time when these measurements were taken, there were no significant groundwater/surface water interactions.

Table 1: Seepage Study Site Discharge Comparison

Site	Qm (cfs)	Qc (cfs)	Qm-Qc (cfs)
3336900	24.10		
SSD	0.30		
SF1	26.45	24.40	2.05
SBD	32.80		
3337810	61.61	59.25	2.37
SJ2	1.11		
3337845	60.16	62.72	-2.56
SJ3	1.32		
3337848	62.29	61.47	0.81
SJ4	1.22		
3337850	64.29	63.51	0.78
SJ5	3.37		
3337900	63.57	67.66	-4.09
			-0.64

Water Quality

Water quality conditions in the Salt Fork were investigated as part of the stream restoration investigation. Parameters analyzed for possible water quality impairment included bacteria (E. coli), temperature, dissolved oxygen, nutrients, pH, and sediment.

Bacteria Impairment

The level of bacteria impairment in the Salt Fork was determined by taking water quality samples. These samples were collected using hand sampling methods described in the *Introduction to Field Methods for Hydrologic and Environmental Studies* (Figure 19) (Holmes et al. 2001). The samples were then processed following the USGS Microbiology Field Form using the mod mTEC E. coli test. After incubation, colonies of bacteria were counted for each volume filtered. The ideal count was between 20-80 counts and whichever filtered volume count was within this range was scaled in term of counts/100 mL. The results from each sampled site are shown in terms of counts/100 mL (Figure 20).

Figure 19: Josh Cantone Taking a Bacteria Sample (Photo Courtesy of Art Schmidt)

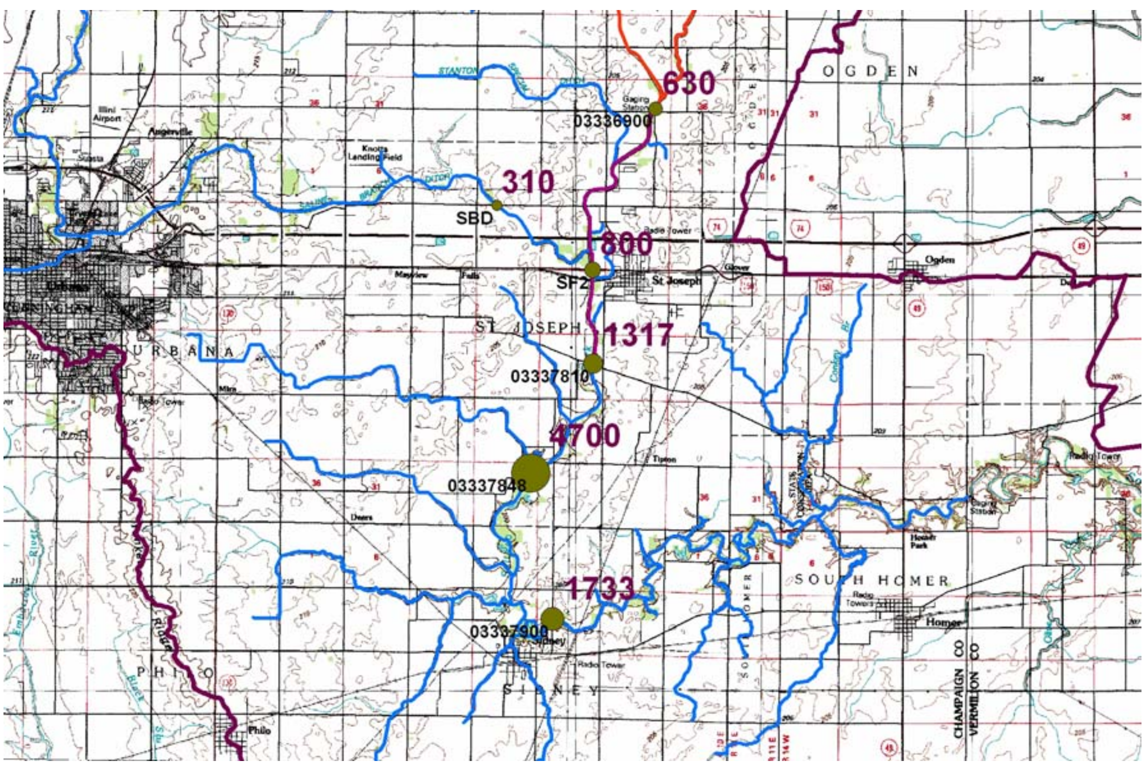

Figure 20: Bacteria Impairment

The Illinois Environmental Protection Agency does not have a water quality standard for E. coli, only fecal coliforms (IEPA 2006). The maximum E. coli level for recreational waters based on U.S. Environmental Protection Agency guidelines is 235 colonies/100 mL (IDPH 2007). According to the data collected, all sampled sites exceed this standard. The problem with the data collected was that only one sample was taken at each site instead of what should have been five samples at each site then reporting the median value. In addition, some of the samples taken were dipped into the water multiple times which could have contaminated the sample or resulted in higher than normal bacteria levels. The sample taken at the Sidney gage was resampled more than any other samples taken and had the highest bacteria count of any of the sampled sites. This data should be used with caution. There were not enough data samples to say anything of value. But assuming the data was reasonable, or at least the values relative to one another, it appears that the St. Joseph WWTP located below SF2 was not the cause of the high counts at the Sidney gage. The site at 03337810 should have a higher count if the St. Joseph WWTP was responsible for the elevated counts. The elevated bacteria counts could be from septic tank leachate. It is difficult to say what caused the elevated counts at the Sidney gage, more accurate data and more detailed data along this reach would be necessary to identify the probable source.

Temperature

Temperature data was collected at two sites on the Salt Fork. Temperature data collected at the St. Joseph gage was provided by the USGS. Temperature data at Sidney was collected using a YSI water quality probe installed by Art Schmidt. The temperature data collected at the two sites is shown in Figure 21. At both sites the temperature peaks in the late afternoon to early evening and is lowest in the morning. The daily fluctuations in water temperature reflect diurnal patterns. The water temperature at the St. Joseph gage exhibited greater fluctuations than at the Sidney gage. When the reach upstream of the St. Joseph gage was dredged the vegetation along the stream corridor was removed causing the stream to become more sensitive to temperature variations (Figure 2). The corridor just upstream and along the Sidney gage has adequate vegetation to act as a water temperature buffer (Figure 3).

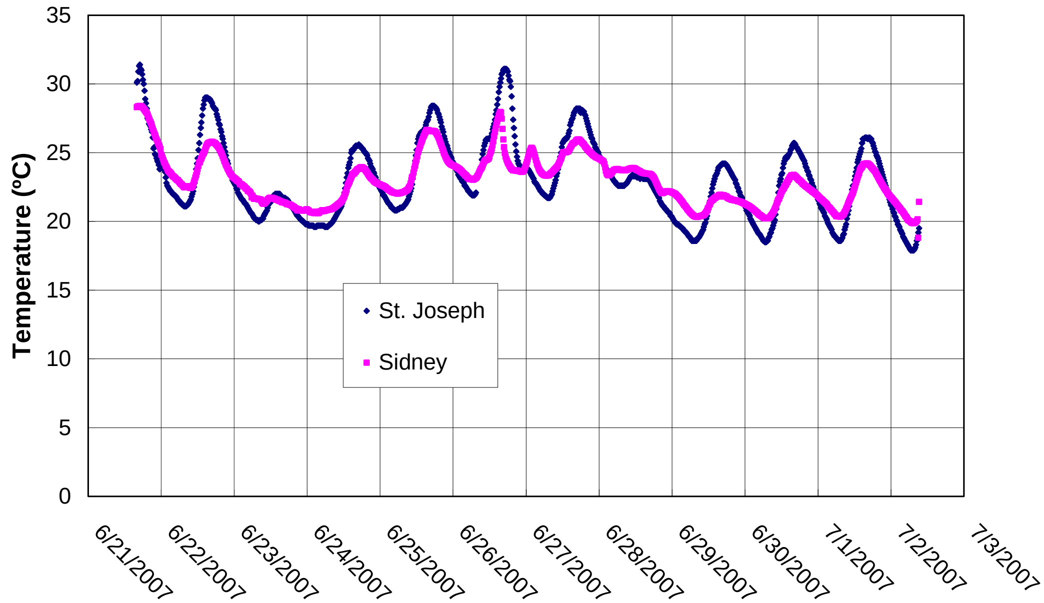

Figure 21: Spatial and Temporal Temperature Variations

Dissolved Oxygen

The YSI water quality probe installed by Art Schmidt at the Sidney gage not only collected temperature data but also dissolved oxygen (DO) and chlorophyll concentration (Figure 22). The dissolved oxygen concentration reflects diurnal fluctuations similar to temperature. These diurnal fluctuations in DO were due to plant photosynthesis. During the hours of sunlight the plants were producing oxygen through photosynthesis and at night this oxygen was being used. The concentration of chlorophyll during this same time period affects the dissolved oxygen concentration. This would make sense because the plants are the ones producing the oxygen. Diurnal fluctuations in plant production explain the causes for the temporal variability of the dissolved oxygen concentration.

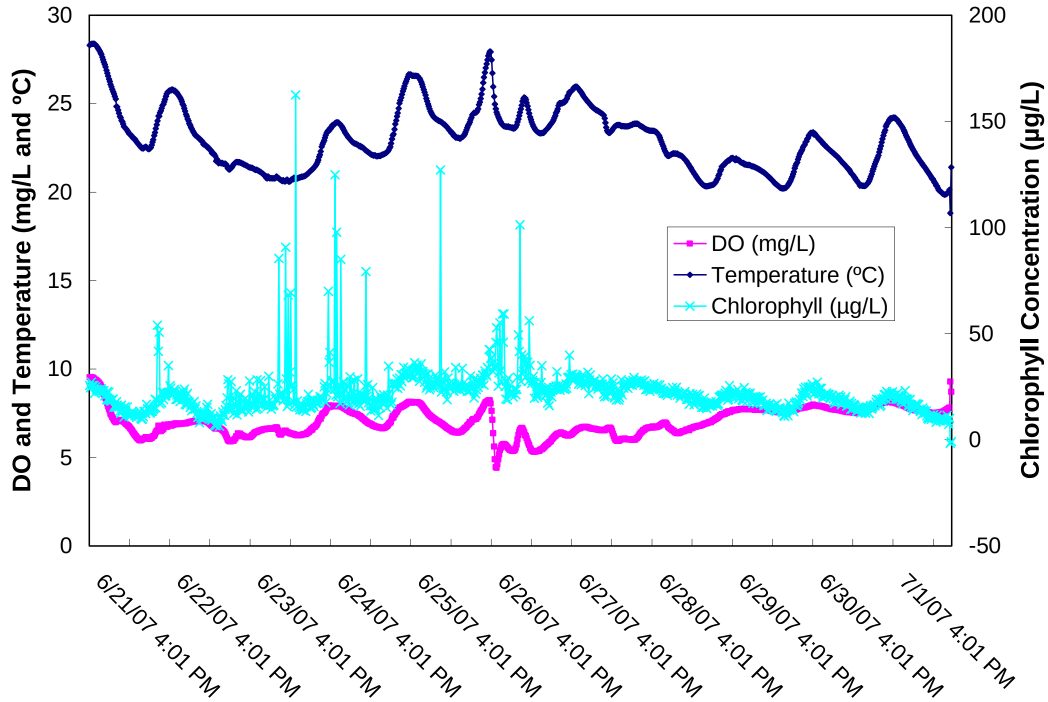

Figure 22: Temporal Variability of Dissolved Oxygen, Temperature, and Chlorophyll

The water quality standard for dissolved oxygen in the Salt Fork is that it shall not be less than 6.0 mg/L during at least 16 hours of any 24 hour period, nor less than 5.0 mg/L at any time (IEPA 2006). The period of time when the YSI water quality probe collected dissolved oxygen data, the water quality standard for dissolved oxygen was violated (Figure 23).

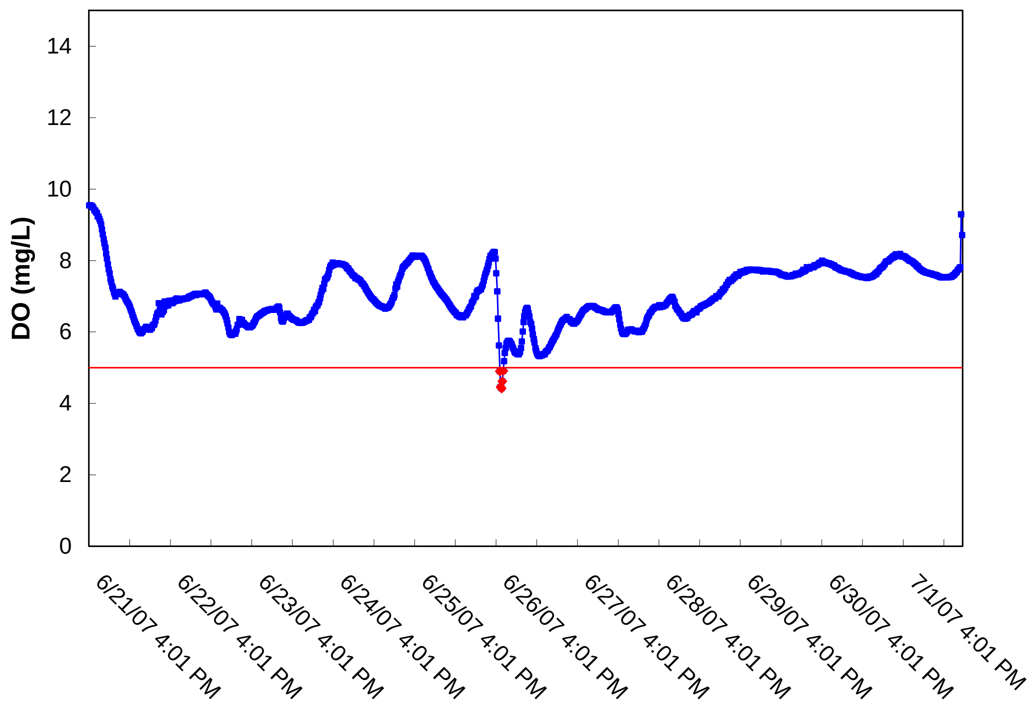

Figure 23: Dissolved Oxygen in the Salt Fork at the Sidney Gage

Nutrients

Water quality samples were taken at the Sidney and St. Joseph gages on June 19, 2007 and sent to the lab to be analyzed for specific constituents. The water quality samples were collected following standard USGS procedures. The constituents of interest were nutrient concentrations, nitrate and phosphorous.

The water quality standard for nitrate in the Salt Fork is 10 mg/L (IEPA 2006). The sample collected at the Sidney gage reported a concentration of 15.7 mg/L and the sample collected at the St. Joseph gage reported a concentration of 7.2 mg/L. The concentrations reported were for nitrates in filtered water in mg/L as nitrate. The one sample taken at the Sidney gage exceeded the water quality standard.

There is no water quality standard for phosphorous in the Salt Fork. There is however, a guideline that can determine if the water body is impaired for aquatic life. This guideline is 0.61

mg/L for phosphorous (IEPA 2006). The sample collected at the Sidney gage reported a concentration of 0.83 mg/L and the sample collected at the St. Joseph gage reported a concentration of 0.52 mg/L. The concentrations reported were for phosphorous in filtered water in mg/L. The one sample taken at the Sidney gage exceeded the water quality guideline.

The results from the one water quality sample indicate that there are high nutrient levels at the Sidney gage. More water quality samples should be taken to verify these nutrient levels.

pH

The YSI water quality probe installed by Art Schmidt at the Sidney gage collected pH for the same period of time as the parameters previously mentioned. The water quality standard for pH in the Salt Fork is between 6.5 and 9.0 (IEPA 2006). Based on the minimal data collected, the Salt Fork at the Sidney gage did not violate the water quality standard for pH (Figure 24).

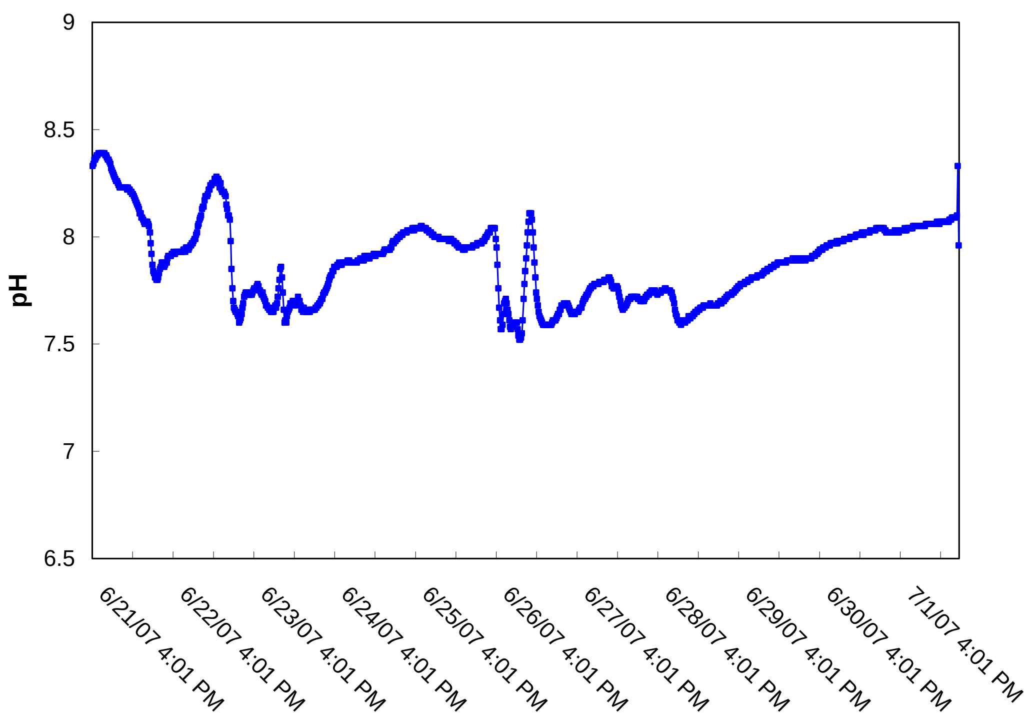

Figure 24: pH measured at the Sidney Gage

Sediment

Excess sediment impairs water quality. To quantify the sediment impairment in the Salt Fork, data was collected at the Sidney gage. Turbidity measured in Nephelometric Turbidity Units (NTUs) was collected by an OBS sensor, which took measurements every 15 minutes. It appears that the OBS sensor was not capable of measuring turbidity over 1000 NTUs because high turbidity values always seem to peak just below this value (Figure 26). Sediment concentration data was collected every so often by Bob Holmes using standard collection techniques outlined in his Sediment Transport lecture given on June 18, 2007 (Figure 25). More NTU data was collected than concentration data. Since determining sediment load requires concentration rather than NTUs, the NTU data was scaled to estimate concentration (Figure 26). From looking at the data, it appeared that high NTU values should be scaled differently than low values. For values less than 200 NTUs, a scale factor of 1.5 was used and for values greater than 200 NTUs a value of 0.6 was used. The scale factors for NTU data were obtained by visual inspection of the scaled graph. The visual “best fit" is shown in Figure 27.

Figure 25: Bob Holmes Collecting Suspended Sediment Samples (Photo Courtesy of Davide Motta)

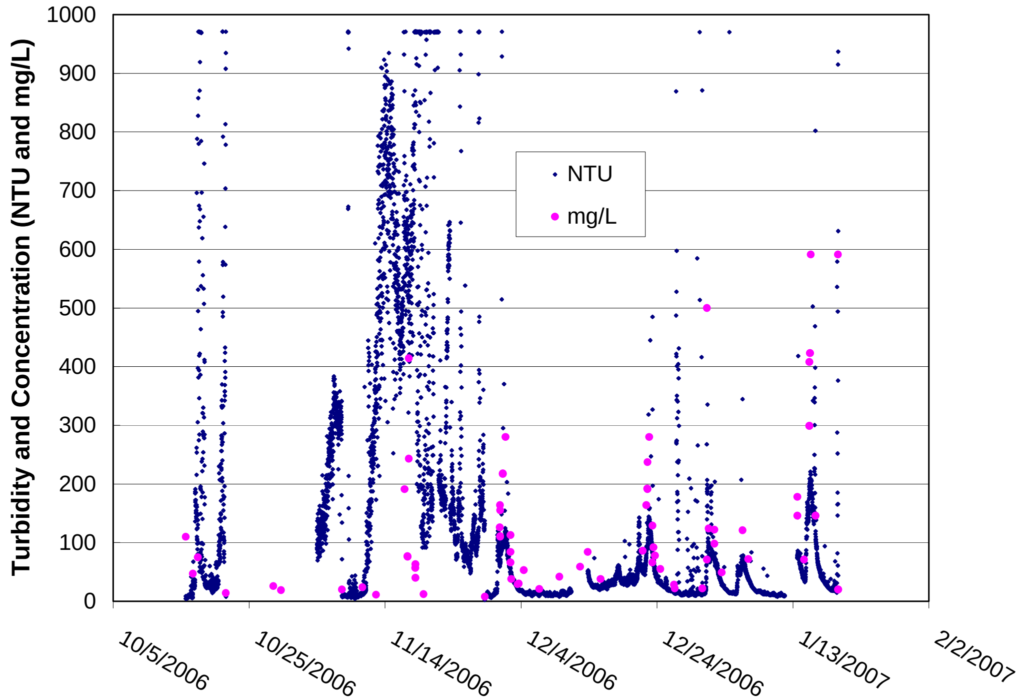

Figure 26: Unadjusted Turbidity and Concentration

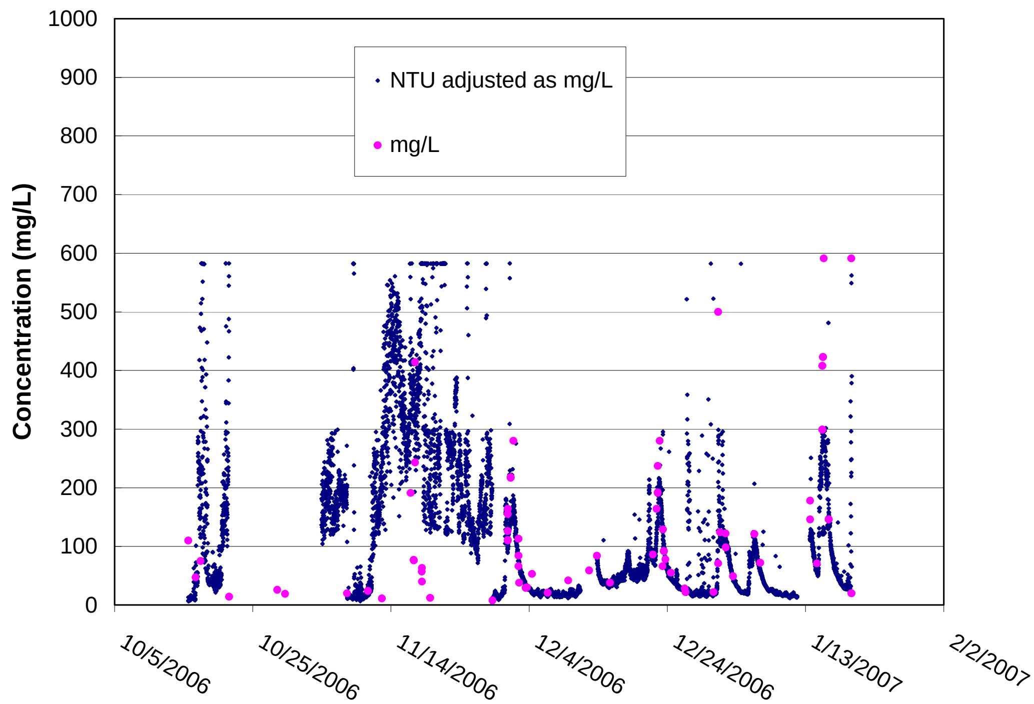

Figure 27: Turbidity Scaled to Concentration

The scaled 15 minute NTU to concentration data was used to quantify sediment impairment. The 15 minute concentration data was averaged into daily values. The daily concentration values in mg/L were multiplied by concurrent daily discharge values in cfs and a unit conversion factor of 0.0027 in order to obtain daily sediment loads in tons/day. After filtering out bad data, only 199 data points or daily sediment concentration values were obtained. These spanned from mid October 2006 to mid June 2007. Since some months had more data than others and some had no data at all, all of the daily loads were averaged together to obtain an average daily load. This value was multiplied by 365 days/year resulting in an annual sediment load of 34600 tons/year. The maximum and minimum daily loads during the time of data collection were 1530 tons/day and 1.18 tons/day respectively. The maximum and minimum daily concentrations during the time of data collection were 470 mg/L and 5.6 mg/L respectively.

There is no water quality standard for total suspended sediment in the Salt Fork. There is however, a guideline that can determine if the water body is impaired for aquatic life. This guideline is 116 mg/L for total suspended sediment (IEPA 2006). The data collected indicate that this guideline is exceeded quite often at the Sidney gage.

Monthly sediment loads were calculated and plotted to determine the possibility of seasonal effects (Figure 28). Seasonal effects would be expected if agricultural best management practices such as leaving crop residue on the fields and utilizing buffer strips were not incorporated. This graph shows a plot of monthly sediment load over time and the corresponding percentage of days in the month missing from the monthly average. The monthly sediment loads suggest that December and January contribute higher sediment loads than the other months during the period of data collection. This may not be the case. The bars show that there are fewer days in the monthly average for the months with lower sediment loads than those with higher sediment loads. The missing data could have been from days of high sediment loads; therefore averaging all of the days of the month together might not show a seasonal effect. Although it is still possible that there are seasonal effects, too many days are missing outside of the winter months to say anything meaningful.

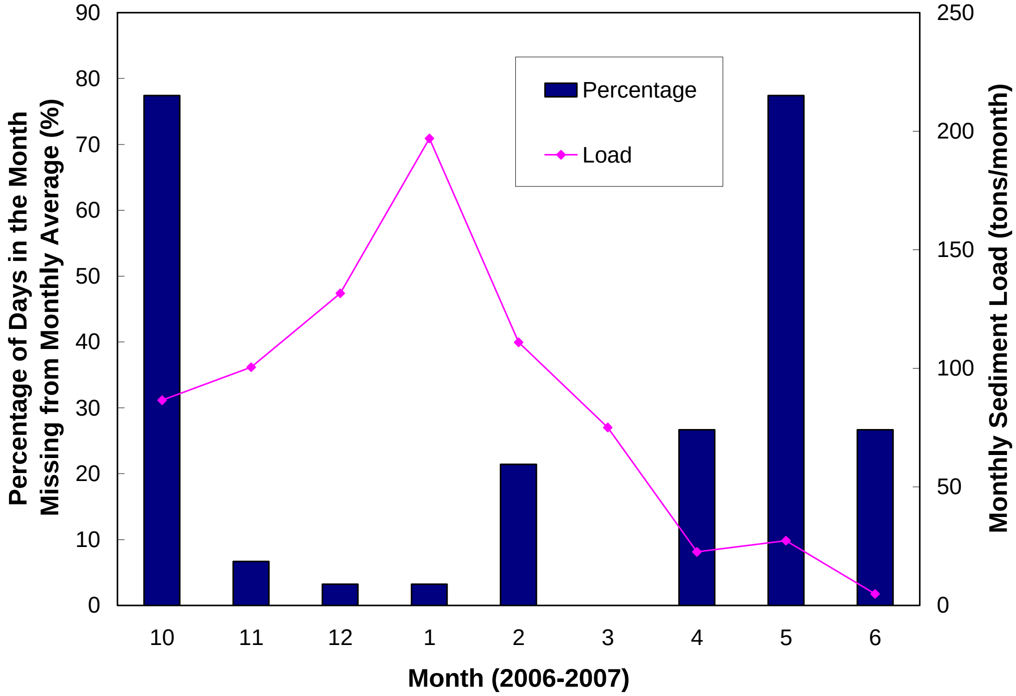

Figure 28: Monthly Sediment Load

Sidney Gage Floodplain Site Conditions

The site conditions in the floodplain at the Sidney gage were evaluated to determine the feasibility of implementing a stream restoration project in this area. It is thought that a constructed wetland would be a good enhancement to the ecosystem at the Sidney gage. According to the landowner, Bob Holmes, the previous land owner attempted to construct a pond at this site in the floodplain of the Salt Fork (Figure 29). During a flood event the pond would fill up with water first and then the floodplain would become inundated, indicating that the pond was hydraulically connected to the stream. When the water receded the pond emptied within a few days. He also noted that the floodplain would become inundated a few times per year. The pond that was attempted by the previous landowner was fairly shallow and if it were dug deeper or lined with clay, it may have been more effective. In order to determine the feasibility of a constructed wetland, a Geoprobe was used to collect a soil core and to install a shallow groundwater well in the floodplain at the Sidney gage (Figure 30). The coring and installation of the well was performed following standard USGS guidelines (Lapham et al. 1997).

Figure 29: Floodplain at the Sidney Gage (Photo Courtesy of Bob Holmes)

Figure 30: Pat Mills Collecting a Soil Core with the Geoprobe (Photo Courtesy of Davide Motta)

Soil Profile

The soil core was collected by Pat Mills and Jon Czuba. Gary Johnson of the USGS was on hand assisting. The soil core collected is shown in Figure 31. The soil core was collected in four sections. The sections are in order from shallowest to deepest from right to left with the top of the section at the top of the picture. Each section should theoretically have four feet of soil; this is only true for the first section. The second and third sections of the soil core appear to have lost soil due to compression during coring. The fourth section of the soil core was not cored for the full four feet because the confining layer was reached. An interpretation of the soil column in the floodplain at the Sidney gage is shown in Figure 32. For the most part, the column shown follows the field notes taken by Pat Mills. Near the bottom of the third section gray “gravel” was encountered. This “gravel” is shown at the bottom of Figure 31 in between section three and four. This gravel is strikingly similar to the clay in section four. Pat’s notes indicate that the first foot of section four is tan silty sand which it appears to be in Figure 31. During a cursory review of the top of section four when opened, beneath a thin layer of silty sand was the clay which connected the bottom of section three to the rest of section four. When section three was removed from the coring hole, some of the wet silty sand slumped down to the bottom of the hole. Upon driving section four into the coring hole, the wet silty sand that slumped down was smeared on the outer portion of the top of section four. The interpretation of the soil profile in Figure 32 corrects this inconsistency. The other sections were not verified with the field notes because the soil core was discarded sooner than expected.

Figure 31: Soil Core from the Sidney Gage (Photo Courtesy of Art Schmidt)

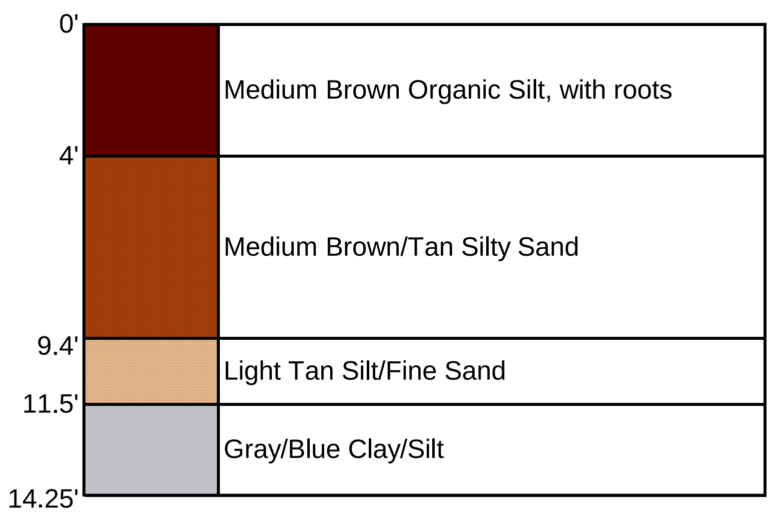

Figure 32: Soil Profile from the Sidney Gage

Floodplain Inundation

The bank-full discharge of the Salt Fork at the Sidney gage is 2000 cfs. This discharge corresponds to a stage of 10 ft (Figure 4) which corresponds to an elevation of 653.3 ft (Figure 33). The channel cross section verifies that this is an accurate estimate of the bank-full discharge. The exceedence probability of the bank-full discharge is around 1.5% (Figure 6). This means that the Salt Fork will inundate its floodplain at the Sidney gage a few times per year which verifies Bob Holmes' testimony.

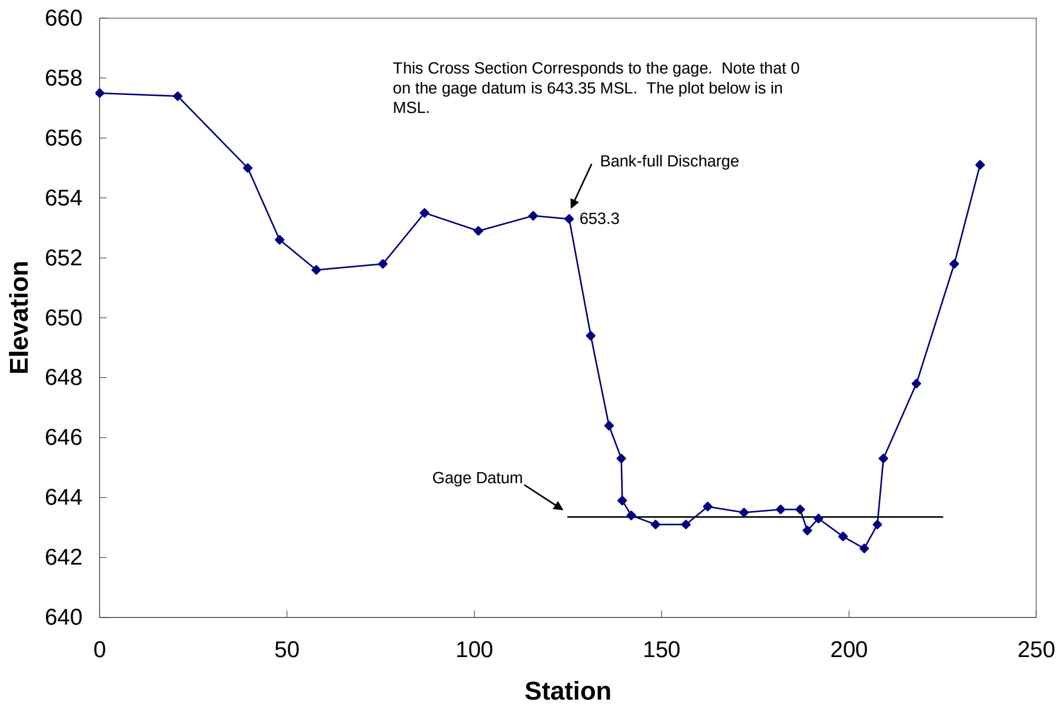

Figure 33: Channel Cross Section at the Sidney Gage with Gage Datum

Groundwater

After the soil core was taken a well was installed in the same hole. Approximately 5 minutes after developing the well, a groundwater level was taken. This level corresponds to an elevation of 645 ft. This is reasonable because that was the approximate water level in the Salt Fork at the time. It also indicates that the well and the Salt Fork are hydraulically connected. Other groundwater data was collected after the well was installed but was not used because of concerns about its quality.

Wetland/Pond Feasibility

The pond attempted in the floodplain at the Sidney gage by the previous land owner was not dug deep enough and within soil horizons that were not conducive to retaining water. A wetland/pond is feasible in the floodplain at the Sidney gage if designed properly. Since the groundwater in the floodplain is hydraulically connected to the Salt Fork, a wetland would only need to be dug deep enough to intersect the groundwater level. Based on the stage data in the Salt Fork and the flow duration curve, it is possible to estimate the frequency a certain groundwater elevation will attain. Multiple terraces could be constructed in the floodplain at different elevations to match certain frequencies of saturation. Wetland plants could then be chosen based on the frequency of saturation. If an area was excavated deep enough, to the top of the confining layer, water would remain in this excavation continually, unless the Salt Fork dries up. This would create a pond in the floodplain. The water level in the pond would fluctuate with the water surface elevation of the Salt Fork. The water level fluctuations in the pond could be dampened by lining part of the pond with clay or some other semi-impermeable material. If the pond were lined, more than likely the semi-impermeable layer would have to be overtopped by the groundwater in order for the pond to fill up.

It is difficult to assess the water quality impact this wetland/pond would have on the Salt Fork. There has not been enough research on quantifying the affects wetlands have on water quality to make a judgment. It is also unknown that if the wetland did impact the water quality in the Salt Fork, would this impact be significant enough to make a difference? Also, would this wetland be providing a water quality benefit during the flows where it is needed the most? Possibly this wetland/pond could be monitored along with the Salt Fork to measure its affect on water quality. These points should be considered not only in implementing a wetland/pond at the Sidney gage, but anywhere a stream restoration project would be implemented along the Salt Fork.

Recommendations

The streamflow and water quality conditions in the Salt Fork, as determined from this study and the Draft TMDL report by LimnoTech, should be considered in implementing a stream restoration project in this area. One caveat to consider in using this study is the scant water quality data collected. Some of the water quality data was only collected for two weeks, other data only a few point samples. A rigorous water quality assessment should consider seasonal effects of all constituents. The assessment should also consider data taken during various flow conditions.

The data analyzed in the streamflow section identifies certain conditions in the Salt Fork that should be considered in a stream restoration project such as groundwater/surface water interactions, bed and bank stability, low-flow hydrology, and bank-full discharge. The rating curve and flow duration curve can be used as tools to determine the magnitude of flows likely to occur in the Salt Fork.

A stream restoration project should also seek to alleviate the water quality impairments due to certain constituents. These include bacteria, dissolved oxygen, and nutrients. The Draft TMDL report from LimnoTech also found water quality impairment due to pH, which this investigation did not find from its limited data, but should also be considered. While no standard is set for total suspended solids in the Salt Fork, the IEPA guidelines for aquatic life deem this as impairment.

In order to protect riparian habitat, a stream restoration project should be implemented that does not require maintenance dredging. This would save the riparian trees and maintain the water temperature buffering affect they have on the Salt Fork.

Perhaps the most appropriate solution for alleviating the Salt Fork's water quality impairments would be to implement multiple stream restoration projects. One project that has been suggested is to implement a wetland/pond in the floodplain at the Sidney gage. Whatever stream restoration project is considered, I hope an integrated watershed approach is taken that alleviates the Salt Fork's water quality impairments.

References

Holmes, Bob. Sediment Transport: Monitoring and Evaluation. CEE 498FM Lecture, June 18, 2007.

Illinois Department of Public Health, (IDPH). (2007). http://www.idph.state.il.us/envhealth/beachhome.htm. Accessed August 9, 2007.

Illinois Environmental Protection Agency, (IEPA). (2006). Illinois Integrated Water Quality Report and Section 303(d) List – 2006. http://www.epa.state.il.us/water/water-quality/report-2006/2006-report.pdf. Accessed August 16, 2007.

Lapham, Wayne W., Wilde, Franceska D., and Koterba, Michael T., (1997). Guidelines and standard procedures for studies of ground-water quality; selection and installation of wells, and supporting documentation. U.S. Geological Survey Water-Resources Investigations Report 96-4233.

LimnoTech. (2007). Draft TMDL: Salt Fork Vermillion River Watershed. http://www.epa.state.il.us/water/tmdl/report/salt-vermilion/salt-vermilion-stage3-draft-tmdl.pdf. Accessed August 16, 2007.

Nortek. CollectV Software Manual Version 3.2, 2000.

Nortek. Nortek 10 MHz Velocimeter Operations Manual, November 1, 2000.

Appendix

Table 2: Salt Fork at Sidney Rating Table

Discharge (cfs)

Gage Height	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.8									35.8	36.6
0.9	37.4	38.3	39.1	40.0	41.0	42.0	43.0	44.0	45.0	46.0
1.0	47.0	48.0	49.0	50.0	51.0	52.0	53.1	54.1	55.1	56.1
1.1	57.1	58.2	59.2	60.2	61.3	62.3	63.3	64.4	65.4	66.5
1.2	67.5	68.5	69.6	70.6	71.7	72.7	73.8	74.9	75.9	77.0
1.3	78.0	79.1	80.2	81.2	82.3	83.4	84.5	85.5	86.6	87.7
1.4	88.8	89.9	91.0	92.1	93.1	94.2	95.3	96.4	97.5	98.6
1.5	99.7	100.8	101.9	103.1	104.2	105.3	106.4	107.5	108.6	109.8
1.6	110.9	112.0	113.1	114.2	115.4	116.5	117.6	118.8	119.9	121.0
1.7	122.2	123.3	124.4	125.6	126.7	127.9	129.0	130.2	131.3	132.5
1.8	133.6	134.8	135.9	137.1	138.2	139.4	140.6	141.7	142.9	144.0
1.9	145.2	146.4	147.6	148.7	149.9	151.1	152.3	153.4	154.6	155.8
2.0	157.0	158.2	159.3	160.5	161.6	162.8	164.0	165.1	166.3	167.5
2.1	168.6	169.8	170.9	172.1	173.3	174.4	175.6	176.8	177.9	179.1
2.2	180.3	181.4	182.6	183.8	184.9	186.1	187.3	188.4	189.6	190.8
2.3	191.9	193.1	194.3	195.5	196.6	197.8	199.0	200.1	201.3	202.5
2.4	203.7	204.8	206.0	207.3	208.6	209.9	211.2	212.6	213.9	215.2
2.5	216.6	217.9	219.3	220.6	222.0	223.4	224.7	226.1	227.5	228.9
2.6	230.3	231.7	233.1	234.5	236.0	237.4	238.8	240.3	241.7	243.2
2.7	244.7	246.1	247.6	249.1	250.6	252.1	253.6	255.1	256.6	258.1
2.8	259.6	261.2	262.7	264.2	265.8	267.3	268.9	270.5	272.0	273.6
2.9	275.2	276.8	278.4	280.0	281.5	282.9	284.4	285.9	287.4	288.8
3.0	290.3	291.8	293.3	294.8	296.2	297.7	299.2	300.7	302.2	303.6
3.1	305.1	306.6	308.1	309.6	311.1	312.6	314.1	315.6	317.0	318.5
3.2	320.0	321.5	323.0	324.5	326.0	327.5	329.0	330.5	332.0	333.5
3.3	335.0	336.5	338.0	339.5	341.0	342.5	344.0	345.5	347.0	348.6
3.4	350.1	351.6	353.1	354.6	356.1	357.6	359.1	360.6	362.2	363.7
3.5	365.2	366.7	368.2	369.8	371.3	372.8	374.3	375.8	377.4	378.9
3.6	380.4	381.9	383.5	385.0	386.5	388.1	389.6	391.1	392.7	394.2
3.7	395.7	397.3	398.8	400.3	401.9	403.4	404.9	406.5	408.0	409.6
3.8	411.1	412.6	414.2	415.7	417.3	418.8	420.4	421.9	423.5	425.0
3.9	426.6	428.1	429.7	431.2	432.8	434.3	435.9	437.4	439.0	440.5
4.0	442.1	443.7	445.2	446.8	448.3	449.9	451.5	453.0	454.6	456.2
4.1	457.7	459.3	460.9	462.4	464.0	465.7	467.4	469.1	470.8	472.5
4.2	474.2	475.9	477.6	479.3	481.0	482.7	484.4	486.1	487.9	489.6
4.3	491.3	493.0	494.8	496.5	498.2	500.0	501.7	503.5	505.2	507.0
4.4	508.7	510.5	512.3	514.0	515.8	517.5	519.3	521.1	522.9	524.6
4.5	526.4	528.2	530.0	531.9	533.7	535.6	537.5	539.4	541.3	543.2
4.6	545.1	547.0	548.9	550.9	552.8	554.7	556.7	558.6	560.6	562.6
4.7	564.5	566.5	568.5	570.5	572.5	574.5	576.5	578.5	580.6	582.6

4.8	584.6	586.7	588.7	590.8	592.9	594.9	597.0	599.1	601.2	603.3
4.9	605.4	607.5	609.6	611.7	613.9	616.0	618.1	620.3	622.4	624.6
5.0	626.8	628.9	631.1	633.3	635.5	637.7	639.9	642.1	644.4	646.6
5.1	648.8	651.1	653.3	655.6	657.8	660.1	662.4	664.6	666.9	669.2
5.2	671.5	673.8	676.1	678.4	680.8	683.1	685.4	687.8	690.1	692.5
5.3	694.9	697.2	699.6	702.0	704.4	706.8	709.2	711.6	714.0	716.4
5.4	718.9	721.3	723.7	726.2	728.6	731.1	733.6	736.0	738.5	741.0
5.5	743.5	746.0	748.5	751.0	753.5	756.1	758.6	761.1	763.7	766.2
5.6	768.8	771.4	773.9	776.5	779.1	781.7	784.3	786.9	789.5	792.1
5.7	794.7	797.4	800.0	802.6	805.3	807.9	810.6	813.3	816.0	818.6
5.8	821.3	824.0	826.7	829.4	832.1	834.9	837.6	840.3	843.1	845.8
5.9	848.6	851.3	854.1	856.9	859.6	862.4	865.2	868.0	870.8	873.6
6.0	876.5	879.3	882.1	884.9	887.8	890.6	893.5	896.4	899.2	902.1
6.1	905.0	907.9	910.8	913.7	916.6	919.5	922.4	925.4	928.3	931.2
6.2	934.2	937.1	940.1	943.1	946.0	949.0	952.0	955.0	958.0	961.0
6.3	964.0	967.0	970.1	973.1	976.1	979.2	982.2	985.3	988.4	991.4
6.4	994.5	997.6	1000.7	1003.8	1006.9	1010.0	1012.6	1015.1	1017.7	1020.3
6.5	1022.8	1025.4	1027.9	1030.5	1033.1	1035.7	1038.2	1040.8	1043.4	1045.9
6.6	1048.5	1051.1	1053.7	1056.2	1058.8	1061.4	1064.0	1066.5	1069.1	1071.7
6.7	1074.3	1076.9	1079.4	1082.0	1084.6	1087.2	1089.8	1092.4	1094.9	1097.5
6.8	1100.1	1102.7	1105.3	1107.9	1110.5	1113.1	1115.7	1118.3	1120.9	1123.4
6.9	1126.0	1128.6	1131.2	1133.8	1136.4	1139.0	1141.6	1144.2	1146.8	1149.4
7.0	1152.0	1154.6	1157.2	1159.9	1162.5	1165.1	1167.7	1170.3	1172.9	1175.5
7.1	1178.1	1180.7	1183.3	1186.0	1188.6	1191.2	1193.8	1196.4	1199.0	1201.6
7.2	1204.3	1206.9	1209.5	1212.1	1214.8	1217.4	1220.0	1222.6	1225.2	1227.9
7.3	1230.5	1233.1	1235.8	1238.4	1241.0	1243.6	1246.3	1248.9	1251.5	1254.2
7.4	1256.8	1259.4	1262.1	1264.7	1267.3	1270.0	1272.6	1275.3	1277.9	1280.5
7.5	1283.2	1285.8	1288.5	1291.1	1293.8	1296.4	1299.1	1301.7	1304.4	1307.0
7.6	1309.6	1312.3	1315.0	1317.6	1320.3	1322.9	1325.6	1328.2	1330.9	1333.5
7.7	1336.2	1338.8	1341.5	1344.2	1346.8	1349.5	1352.1	1354.8	1357.5	1360.1
7.8	1362.8	1365.5	1368.1	1370.8	1373.5	1376.1	1378.8	1381.5	1384.1	1386.8
7.9	1389.5	1392.2	1394.8	1397.5	1400.2	1402.9	1405.5	1408.2	1410.9	1413.6
8.0	1416.3	1418.9	1421.6	1424.3	1427.0	1429.7	1432.4	1435.0	1437.7	1440.4
8.1	1443.1	1445.8	1448.5	1451.2	1453.9	1456.6	1459.3	1461.9	1464.6	1467.3
8.2	1470.0	1472.7	1475.4	1478.1	1480.8	1483.5	1486.2	1488.9	1491.6	1494.3
8.3	1497.0	1499.7	1502.4	1505.1	1507.9	1510.6	1513.3	1516.0	1518.7	1521.4
8.4	1524.1	1526.8	1529.5	1532.2	1535.0	1537.7	1540.4	1543.1	1545.8	1548.5
8.5	1551.3	1554.0	1556.7	1559.4	1562.1	1564.9	1567.6	1570.3	1573.0	1575.8
8.6	1578.5	1581.2	1583.9	1586.7	1589.4	1592.1	1594.9	1597.6	1600.3	1603.1
8.7	1605.8	1608.5	1611.3	1614.0	1616.7	1619.5	1622.2	1625.0	1627.7	1630.4
8.8	1633.2	1635.9	1638.7	1641.4	1644.2	1646.9	1649.7	1652.4	1655.1	1657.9
8.9	1660.6	1663.4	1666.1	1668.9	1671.7	1674.4	1677.2	1679.9	1682.7	1685.4
9.0	1688.2	1690.9	1693.7	1696.5	1699.2	1702.0	1704.7	1707.5	1710.3	1713.0
9.1	1715.8	1718.6	1721.3	1724.1	1726.9	1729.6	1732.4	1735.2	1738.0	1740.7
9.2	1743.5	1746.3	1749.0	1751.8	1754.6	1757.4	1760.1	1762.9	1765.7	1768.5
9.3	1771.3	1774.0	1776.8	1779.6	1782.4	1785.2	1788.0	1790.8	1793.5	1796.3
9.4	1799.1	1801.9	1804.7	1807.5	1810.3	1813.1	1815.9	1818.7	1821.4	1824.2
9.5	1827.0	1829.8	1832.6	1835.4	1838.2	1841.0	1843.8	1846.6	1849.4	1852.2

9.6	1855.0	1857.8	1860.6	1863.5	1866.3	1869.1	1871.9	1874.7	1877.5	1880.3
9.7	1883.1	1885.9	1888.7	1891.6	1894.4	1897.2	1900.0	1906.3	1912.6	1919.0
9.8	1925.3	1931.7	1938.1	1944.6	1951.0	1957.5	1964.0	1970.5	1977.1	1983.6
9.9	1990.2	1996.8	2003.4	2010.1	2016.8	2023.5	2030.2	2036.9	2043.7	2050.4
10.0	2057.2	2064.1	2070.9	2077.8	2084.7	2091.6	2098.5	2105.5	2112.4	2119.4
10.1	2126.5	2133.5	2140.6	2147.7	2154.8	2161.9	2169.0	2176.2	2183.4	2190.6
10.2	2197.9	2205.1	2212.4	2219.7	2227.0	2234.4	2241.7	2249.1	2256.5	2264.0
10.3	2271.4	2278.9	2286.4	2293.9	2301.5	2309.0	2316.6	2324.2	2331.9	2339.5
10.4	2347.2	2354.9	2362.6	2370.3	2378.1	2385.9	2393.7	2401.5	2409.4	2417.2
10.5	2425.1	2433.0	2441.0	2448.9	2456.9	2464.9	2472.9	2481.0	2489.0	2497.1
10.6	2505.2	2513.3	2521.5	2529.7	2537.9	2546.1	2554.3	2562.6	2570.9	2579.2
10.7	2587.5	2595.8	2604.2	2612.6	2621.0	2629.4	2637.9	2646.4	2654.9	2663.4
10.8	2671.9	2680.5	2689.1	2697.7	2706.3	2715.0	2723.7	2732.4	2741.1	2749.8
10.9	2758.6	2767.4	2776.2	2785.0	2793.8	2802.7	2811.6	2820.5	2829.5	2838.4
11.0	2847.4	2856.4	2865.4	2874.5	2883.5	2892.6	2901.7	2910.8	2920.0	